ARCMG

Institute for Materials Reseach, Tohoku University

Advanced Research Center of Metallic Glasses

Further Progress of New Materials Research

Advanced Research Center of Metallic Glasses

Head Takashi Goto

Almost two years have passed since the Laboratory for Advanced Materials (LAM) was reorganized and became the Advanced Research Center of Metallic Glasses (ARCMG) in April 2005. As Prof. Akihisa Inoue, the first director of ARCMG, was inaugurated as the 20th president of Tohoku University in November 2006, I succeeded him as the director of ARCMG. Your understanding and cooperation will be much appreciated.

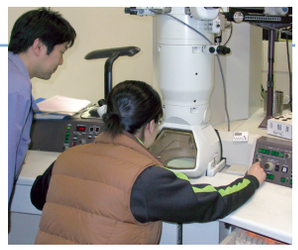
ARCMG originates from the Laboratory for Advanced Materials (LAM) (which was established as "Laboratory for Developmental Research of Advanced Materials (LDRAM)" in 1987) for "the investigation and application of scientific principles of materials." LAM was composed of two major divisions, one focusing on scientific research that involved investigating the fundamental properties of materials and the other focusing on engineering research that sought to employ materials in industry. In particular, LAM attempted to synthesize and industrialize new materials as the core of its engineering research. Since Prof. Masumoto became the first head of LDRAM, Prof. Nishina, Prof. Fujimori, Prof. Hirai, Prof. Fukuda and Prof. Hanada have endeavored to develop LDRAM (and later LAM) and have contributed to the development of society by creating so many novel materials such as amorphous alloys, nanogranular thin films, nanocomposite ceramics, functionally gradient materials, large oxide monocrystals and titanium-based biomaterials. In particular, bulk metallic glasses have been actively investigated in LAM and the research group of Prof. Inoue et al. has developed new materials that defy the conventional concepts of metallic materials, and has investigated their fundamental properties and their applications as industrial materials. LAM was scheduled to be closed in March 2006 and was subject to a prior external evaluation in fiscal 2003. Since it was recommended that we should further promote research on bulk metallic glasses created in LAM, we decided to set up the ARCMG. Micromotors, pressure sensors, fuel cell separators and many other devices that use bulk metallic glasses are about to become practical propositions.

To promote research into various new materials in addition to metallic glasses, the ARCMG is also taking responsibility for being a nationwide joint laboratory by allowing its research facilities to be used by researchers throughout the country and widely appealing to them to be a part of joint research projects. The ARCMG is composed of the Development Research Division, the Applied Research Division, the Industry-University Joint Research Division, and the Research Station. A sub-division "Advanced Materials" installed in Applied Research Division is conducting active investigations of materials other than metallic glasses that can be main objective materials for IMR in future.

Under the leadership of the ARCMG, we initiated the project named "Metallic Glass-Inorganic Materials Joining Technology Development" in fiscal 2005, with the Materials and Structures Laboratory at Tokyo Institute of Technology and the Joining and Welding Research Institute at Osaka University. Under this project, we are promoting the development of new functional materials by merging metallic glasses and ceramics in five fields, namely development of environmental and energy materials, development of electronic materials, creation of advanced biomaterials, nanostructured interface control-joining process and highly functional nanoscale interfaces of dissimilar materials. In addition, a part of our missions is to support the industrialization of materials and to promote international joint research. Since fiscal 2005, in cooperation with Osaka Center of IMR based at Osaka Prefecture University and Overseas Joint Research Center of IMR based at Dalian University of Technology (China), among other goals, we have been striving to develop bulk metallic glasses and other achievements in IMR for practical applications.

Although both metals and glasses have histories of several thousand years in human civilizations, "metallic glasses" are epoch-making materials suitable for the name of "Novel metal era" in the 20th century. We keep striving to further development of the exotic materials created at IMR. Your support and advice for the development of the ARCMG and the practical application researches of the bulk metallic glasses will be sincerely appreciated.

Philosophy and Purpose



When "Laboratory for Developmental Research of Advanced Materials" (LDRAM), (which was renamed as "Laboratory for Advanced Materials" (LAM) in 1996, and currently "Advanced Research Center of Metallic Glasses"), was established, its primary aim was "to develop new materials for supporting technological innovations in the 21st century".

Thus, the underlying philosophy of research in LDRAM was "to find and establish the fundamental principles and technology for synthesizing and controlling artificial substances on an atomic level, and using these fundamental principles and technology, to create new substances, and to search for their potential as highly functional materials and multi-functional materials". Furthermore, the purpose of foundation of LAM, which lasted until fiscal 2004, was carried out to "raising further the seeds of new substances produced, new process technology, and new evaluation methods through the research of Laboratories outside of LAM in IMR, and developing them".

In fiscal 2005, LAM was reorganized and renamed as the Advanced Research Center of Metallic Glasses in order to make a fresh start in promoting research principally on "metallic glasses" which are considered to be the next-generation metallic materials.

Research Subjects

Laboratories of IMR

Synthesis of New Substances & Materials

- Nano-structured Materials
- Environmental and Energy Materials
- Electronics Materials

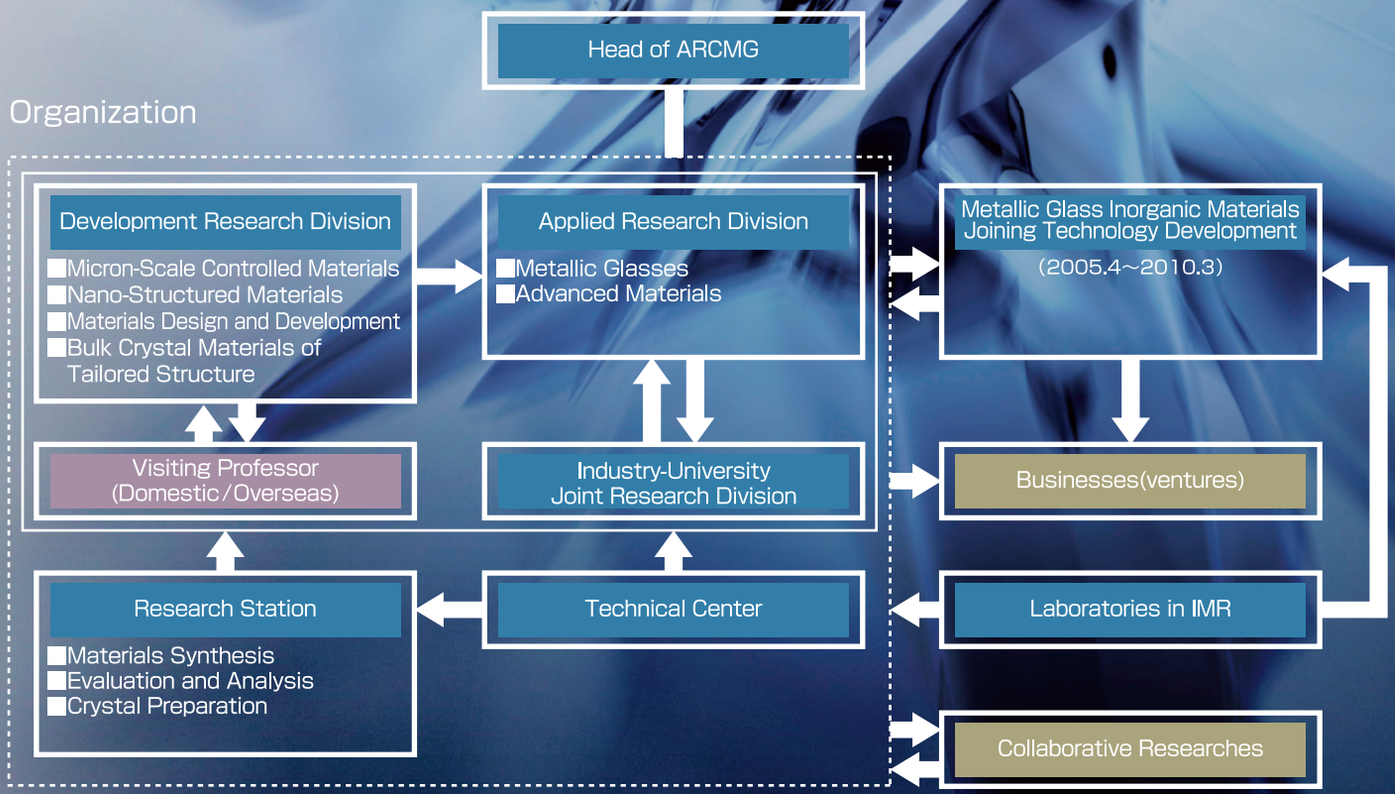
Advanced Research Center of Metallic Glasses

Research & Development

- Metallic Glasses
- Biomaterials
- Energy Materials
- Materials for Severe Environment
- Device Materials
- High Specific Strength Materials
- Materials Designing Software
- Superelastic Materials
- Magnetic Materials
- etc.

New materials for new generation.
It is a state-of-the-art technological field that expands the possibility.

Organization



History

The HEAD	YEAR		Collaborative Research
Tsuyoshi MASUMOTO	1987	■ "Laboratory for Developmental Research of Advanced Materials (LDRAM)" was founded in IMR.	
	1988	■ Four divisions. "Materials Synthesis", "Materials Quality Control", "Evaluation and Analysis" and "Development of Technology" were organized.	
			■Collaborative Researches were started with IMR & extramural research institutes.
			■ "Joint Research" with a Private Company (YKK)
	1990		■ "Joint Research" with a Private Company (TOYOTA)
	1991	■ Two divisions, "Micron-Scale Controlled Materials and "Nano-Structured Materials" were organized.	■NISHINA Project (3years)
Yuichiro NISHINA	1992	■ "Developmental Division" was organized. ■ VisitingProfessors System was Intoroduced.	
	1993		
Tsuyoshi MASUMOTO	1994		
	1995		
Hiroyasu FUJIMORI	1996	■Reorganized to a research laboratory from a research support organization.	■MAEDA Project (3years) ■SUMIYAMA Project (5years)
		■ "Project Research Division", "Technical Servised Division", "Materials Design and Development" and "Materials Functions Search" were organized.	
	1997		
Toshio HIRAI	1998	■Introduction of Responsibility Laboratory System.	
	1999		
Tsuguo FUKUDA	2000	■Renamed to "Laboratory for Advanced Materials (LAM)"	
		■ "Research Division", "Project Division",and "Developmental Division" was renamed and reorganized as "Fundamental Research Division", "Joint Industry University Research Division" and "Research Station".	
	2001		■INOUE Project (4years) ■FUKUDA Project (3years)
Shuji HANADA	2002	■ "Applied Research Division" and "Visiting Professors Division" were organized.	
	2003		
	2004	■External Evaluation	
Akihisa INOUE	2005	■Renamed as "Advanced Research Center of Metallic Glasses", "Metallic Glasses Division" and "Advanced Materials Division" were organized.	■Metallic Glasses -Inorganic Materials Joining Development Colaboration Research Project (5years)
	2006		
Takashi GOTO	2006		
	2007	■ "Bulk Crystal Materials of Tailored Structure" were organized.	

Development Research Division

Micron-Scale Controlled Materials

This division carries out research on synthesizing advanced substances such as amorphous phase, artificial crystalline phase,quasi-crystalline phase and nanocomposite phase, using the vapor phase condensation control method, liquid phase condensation control method and solid phase reaction method through collaborative research win researchers inside and outside the institute. The division is dedicated to establishing micron-scale, structure control techniques for developing sophisticated and multifunctional advanced materials by controlling atomic arrangement and transfer. Furthermore the division evaluates properties, analyzes structure and state for the newly discovered substances. Currently, this division conducts research and development concerning bulk glassy alloys, biomaterials, extremely corrosion resistant materials, environmental cleanup catalytic materials and energy conversion materials.

Materials Design and Development

This group aims to establish a new materials design software system so as to clarify physical properties and developing processes of various materials under tight collaboration with Micron-Scale Controlled Materials and Nano-Structured Materials groups of this laboratory.

Nano-Structured Materials

In this research group, new advanced materials having micron- and/or nano-scale microstructure are designed and produced by manipulating atomic arrangement by using vapor-condensation,rapid-solidification and solid-state-reaction techniques. Particularly, the basic research has been made in order to reveal the origins of high glass forming ability, high strength, high toughness and high fatigue strength of bulk glassy alloys.

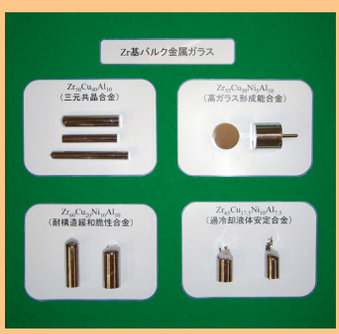
Bulk Crystal Materials of Tailored Structure

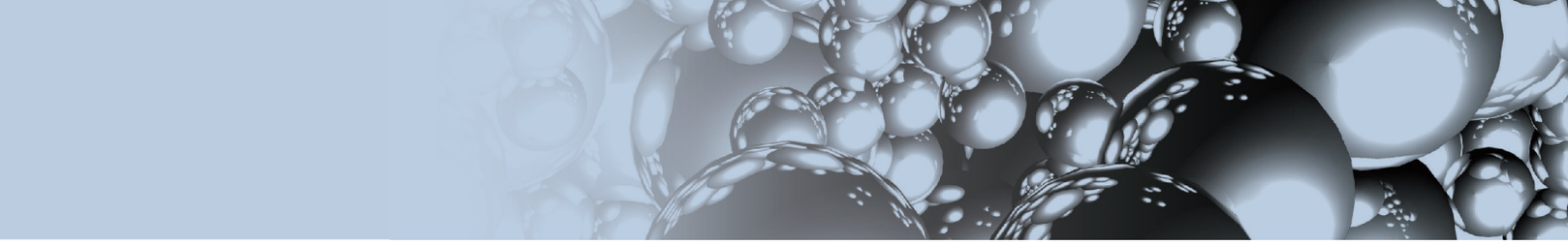
Our mission is to create new bulk crystal materials based on the technological innovations related to crystal growth methods, in close cooperation with researchers from within and outside the institute. Especially, we focus on a variety of crystal materials, including photoelectronic and photomagnetic compounds to support information-oriented society, as well as crystals for development of clean energy.
Specifically, we are actively engaged in the improvement of bulk single crystals of high-functional compounds through the research and development of crystal growth techniques from liquid, gas and solid phases. By assessing the properties of the target materials such as metals, semiconductors, oxides, and halides, an appropriate single crystal growth method is selected from Czochralski-, Bridgman-, floating zone-, flux growth-, hydrothermal-crystal growth-, and molecular-beam epitaxy methods. The appropriate selection of the growth method and growth under optimum conditions will permit to realize high quality crystals.

A i m i n g a t t h e c r e a t i o n o f n e w

Standardization of Bulk Metallic Glasses

In our center, we started global investigation for “Standardization of Bulk Metallic Glasses”. Based on the critical size of several bulk metallic glass, we determine the standard sample size to warrant basic properties.
We summarized standard bulk glassy alloys as followings. We also started new global project to establish the standardization of bulk glassy alloy named “International Working Group for Centimeter Sized Zr-, Ti-, and Cu-based Bulk Glassy Alloys” from14 JAN 2008. (Project Leader: Prof. Youji Shibutani, Osaka Univ.)





Applied Research Division

Objectives of this division is to improve performance of materials which are developed at Development Research Division in ARCMG and also other laboratories in IMR, and to find application of those materials. Currently, we are doing applied researches on bulk metallic glasses with the new functional characteristics, hydrogen storage materials which will be key materials for high-performance fuel cell systems, clean energy materials, biomaterials, energy saving materials, materials for severe environments, etc. with functional characteristics.

Joint Industry-University Research Section

In this division, industry-academia cooperation researches for enterprises and project researches for Japan Science and Technology Organization (JST), New Energy and Industrial Technology Development Organization (NEDO), etc. are actively performed for the metallic glasses, biomaterials, energy saving materials, materials for severe environment, hydrogen energy materials, etc. with the new functional characteristics developed at IMR.

Research Station

The research station consists of three rooms, Materials Synthesis, Evaluation and Analysis, and Crystal Preparation. The research station, equipped with various experiment facilities, supports research work within ARCMG and joint researches with the outside of ARCMG.

- Materials Synthesis
- Evaluation and Analysis
- Crystal Growth

Visiting Professors

There are two posts of visiting professors in ARCMG; one from domestic research institutes and the other one from overseas. We invite those who are actively working in the similar research field we are studying. They study their speciality collaboratively with ARCMG staffs.

v a l u e t h a t o n l y w e c a n d o .

Z Alloy Series

Zr-Based BMGs

- $Zr_{50}Cu_{40}Al_{10}$(Ternary Eutectic) ·····Z1 Alloy
- $Zr_{55}Cu_{30}Ni_5Al_{10}$(High Glass Forming Ability) ·····Z2 Alloy
- $Zr_{60}Cu_{20}Ni_{10}Al_{10}$
  (High Proof to Structural Relaxation Embrittlement) ·····Z3 Alloy
- $Zr_{65}Cu_{17.5}Ni_{10}Al_{7.5}$(High Stability of Supercooled Liquid)··Z4 Alloy

C Alloy Series

Cu-Zr Based BMGs

- $Cu_{36}Zr_{48}Al_8Ag_8$(Migh Glass Forming) ·····C1 Alloy

Cu-Based BMGs

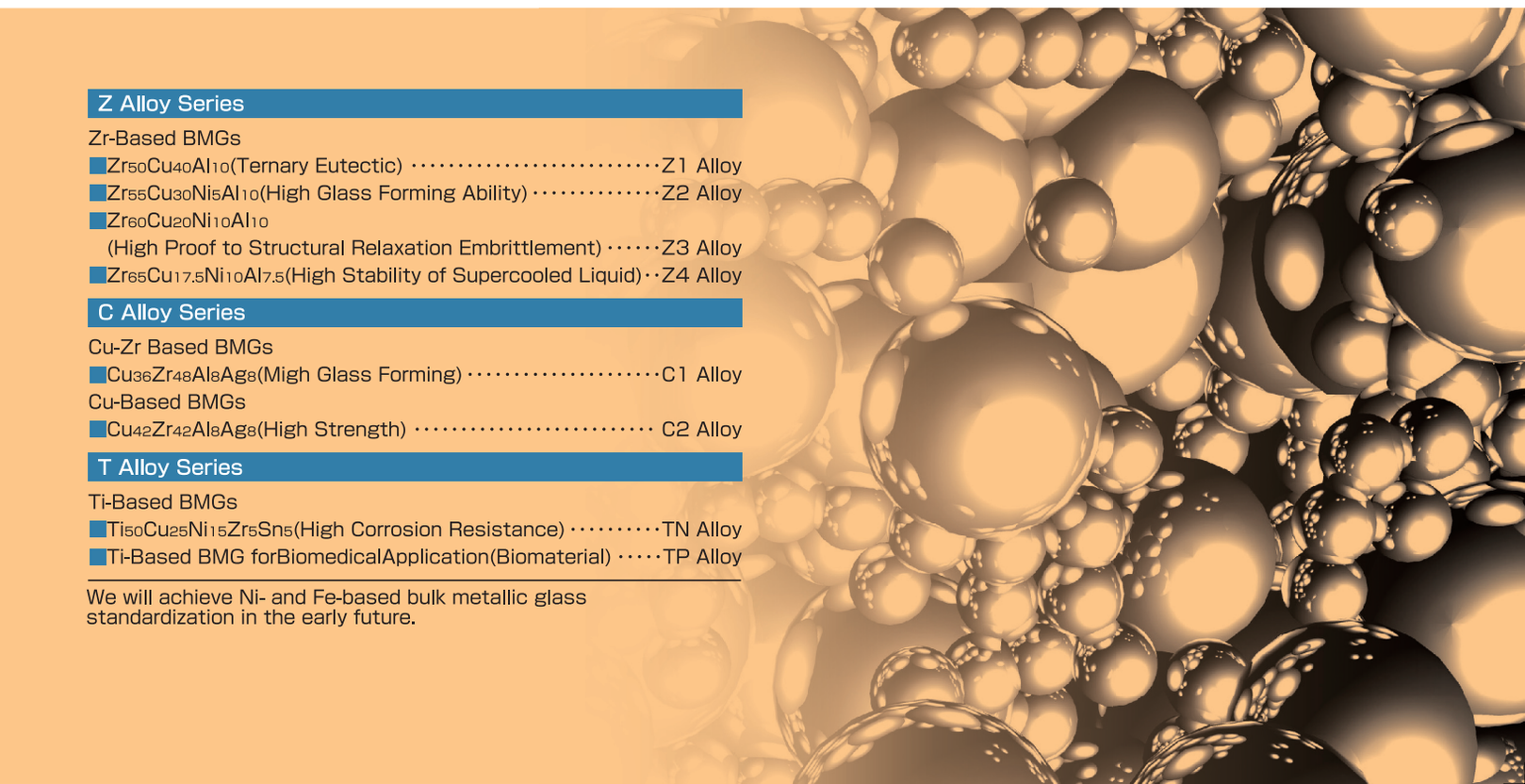
- $Cu_{42}Zr_{42}Al_8Ag_8$(High Strength) ····· C2 Alloy

T Alloy Series

Ti-Based BMGs

- $Ti_{50}Cu_{25}Ni_{15}Zr_5Sn_5$(High Corrosion Resistance) ·····TN Alloy
- Ti-Based BMG forBiomedicalApplication(Biomaterial) ·····TP Alloy

We will achieve Ni- and Fe-based bulk metallic glass standardization in the early future.

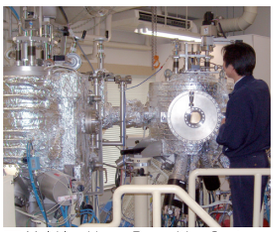


Research Stations

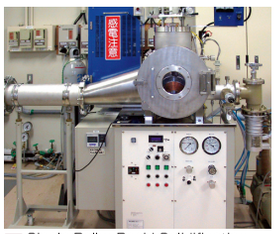
Materials Synthesis

1 Electron Beam Lithography Equipment
2 Multi-Target Reactive Sputtering
3 Electron Beam Vacuum Deposition with Reflection High Energy Electron Diffraction
4 Multi-Ion Vapor Deposition System
5 Multi-Controlled Chemical Vapor Deposition
6 High Temperature Floating Zone Furnace for Composite Ceramics
7 Plasma Spray Apparatus for Composite Fabrication
8 Profile Grinder
9 Ultra-High Temperature Synthesis -Spark Plasma System-
10 Melt-Spinning Equipment in an Atmosphere
11 Electron Beam Cluster Deposition System
12 High Pressure Gas Atomization Equipment
13 Melt-Spinning Equipment in Air
14 Ultra-High Temperature Melt-Spinning Equipment
15 Casting Equipment for Zr-Based Glassy Alloys
16 Casting Equipment for Mg-Based Glassy Alloys

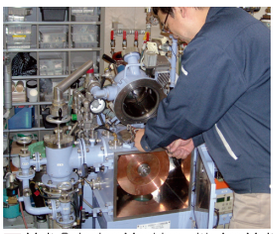

2 Multi-Target Reactive Sputtering


4 Multi-Ion Vapor Deposition System


9 Ultra-High Temperature Synthesis -Spark Plasma System-



10 Single-Roller Rapid Solidification Apparatus in Gases


14 Melt-Spinning Machine with Arc-Melter


15 Tilt Cast Machine for Zr-based BMGs

Procedures for Collaborative Researches with Advanced Research Center of Metallic Glasses

Guidelines for applicants

The purpose of the collaborative researches in IMR is not simply sharing experimental equipments but achieving the targets based on research topics in common with applicants and the ARCMG. Applicants are scholars who develop and study new metallic glasses or various kinds of new materials, and are desired to collaborate with the Research Divisions of the ARCMG by using the equipments in the ARCMG. The collaborative researches without using the equipments are also acceptable. Two applicants are commended for their excellent research results every June by the board of review.

Making Arrangements

(CASE A) Collaborative researches with using experimental equipments

Discuss about research topics (and schedules, if necessary) with the administrators of the equipments. (Check the list of the experimental equipments)

(CASE B) Collaborative researches with the staffs of the Research Divisions of the ARCMG

Discuss about research topics (and schedules, if necessary) with the staffs of the Research Divisions of the ARCMG. (Check the list of the staffs of the Research Divisions of ARCMG)

Submission of Your Research Proposals

Download a form for proposals from WEBSUPPORT site in IMR. After completing the form, submit the proposals to IMR by the deadline, the end of December. (Please contact the ARCMG for the accurate date).

Research Cooperation Section,
IMR, Tohoku Univeristy
Phone: 022-215-2183
imr-kenkyo@imr.tohoku.ac.jp

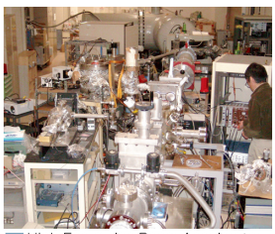
Evaluation and Analysis

1 Micro-X-Ray Photoelectron Spectroscopy
2 Fourier Transformed Infrared Spectrophotometer
3 Photoluminescence Spectrometer
4 Fluorescent X-Ray Analysis
5 Vibrating Sample Magnetometer
6 Scanning Probe Microscope
7 Electron Excitation Imaging System for Solid Surface Analysis
8 Rotating Anode X-Ray Generator for X-Ray Diffraction
9 Micro-X-Ray Diffractometer
10 Micro-Vickers Hardness Tester
11 Vibrating Sample Magnetometer with Temperature Controller
12 Magneto-Resistance Analyzer
13 High Energy Ion-Beam Accelerator for Surface Modification and Analysis
14 Ultrahigh Vacuum Field Ion Scanning Tunneling Microscopy

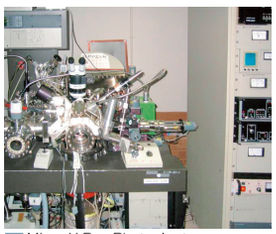

7 Electron Excitation Imaging System for Solid Surface Analysis


5 Vibrating Sample Magnetometer


11 Temperature Variable Vibrating Sample Magneto-Meter


13 High Energy Ion-Beam Accelerator for Surface Modification and Analysis


8 Rotating Anode X-Ray Generator for X-Ray Diffraction

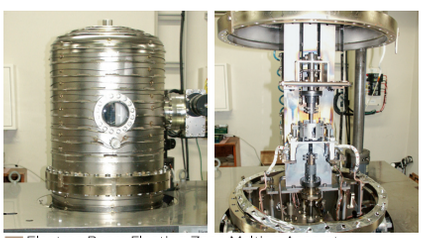

1 Micro-X-Ray Photoelectron Spectroscopy

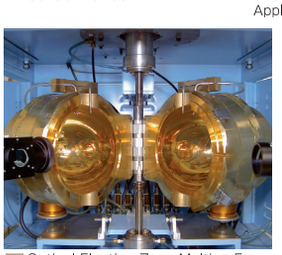
Crystal Growth

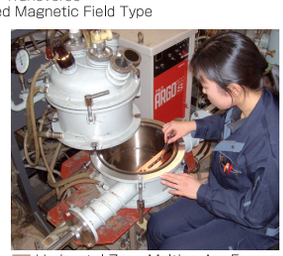
1 High-Temperature Viscosity Measurement System
2 Liquid-Phase Solidification Control Device
3 Crystal Pulling Apparatus of the Transverse Applied Magnetic Field Type
4 Hydrothermal Autoclave
5 Optical Floating Zone Melting Furnace
6 Electron-Beam Floating Zone Melting Apparatus
7 Horizontal Zone Melting Arc Furnace
8 General-Purpose Arc Melting Furnace
9 High-Frequency Heating Single-Crystal Fabrication Apparatus
10 High-Temperature Reaction Sintering Furnace
11 Multi-Chamber Molecular-Beam Epitaxy System

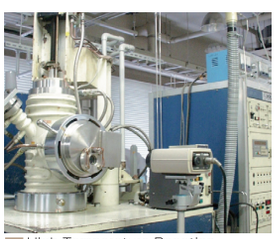

2 Liquid-Phase Solidification Control Device


3 Crystal Pulling Apparatus of the Transverse Applied Magnetic Field Type


6 Electron-Beam Floating Zone Melting Apparatus


5 Optical Floating Zone Melting Furnace


7 Horizontal Zone Melting Arc Furnace


10 High-Temperature Reaction Sintering Furnace

Applicants

Applicants are scholars who are working in IMR or Japanese educational and research institutes, i.e., professors teaching in national / public / private universities and colleges of technology in Japan. The applicants can organize research teams with technicians and graduated students.

For more infomation about collaborative researches, check the following URL

http://www.arcmg.imr.tohoku.ac.jp/en/index.html

Decision

The director of ARCMG decides which proposals to be accepted after the Collaborative Research Committee judges research proposals, and applicants are notified of the decision by the end of March. Proposals answering the concept of the ARCMG and the research subjects of the Research Divisions of the ARCMG are given priority.

Collaborative Research

The period of the Collaborative Research is from April 1 to the end of next February.

Submission of the Collaborative Research Report and List of Publications

By the beginning of next April, submit the Collaborative Research Report and list of publications (download the forms from WEBSUPPORT site in IMR).

TOHOKU
UNIVERSITY

Institute for Materials Reseach,
Tohoku University

Access

1	Honda Memorial Hall	本多記念館
	Administration	事務部
2	Bldg.1	一号館
	Research Laboratories	研究部
3	**Bldg.2**	**二号館**
	Research Laboratories	研究部
	Advanced Research Center of Metallic Glasses 1~3F	金属ガラス総合研究センター
	Library	図書館
4	**Bldg.3**	**三号棟**
	Research Laboratories	研究部
	Advanced Research Center of Metallic Glasses 1~3F	金属ガラス総合研究センター
	Technical Service Division	技術部
5	Research Center	研究棟
	Internatoional Frontier Center for Advanced Materials	材料科学国際フロンティアセンター
6	Technical Plant 1	技術棟1
7	Technical Plant 2	技術棟2
8	Super Computing Center	スーパーコンピューター棟
9	Radiosotope Subcenter	アルファ放射線実験室
10	High Field Laboratory for Superconducting Materials	強磁場超伝導材料研究センター
11	COE Center	COE棟
12	Metallic Glass Inorganic Materials Joining Technology Development	金属ガラス・無機材料接合開発共同研究プロジェクト

Research ARCMG

Advanced Research Center of Metallic Glasses
Institute for Materials Reseach, Tohoku University

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